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# BIOLOGICAL EVALUATION R10-87-1

## HEMLOCK SAWFLY IN SOUTHEAST ALASKA 1981-1986

DECEMBER 1986


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## ABSTRACT

During 1983 and 1984 the hemlock sawfly Neodiprion tsugae reached its highest levels in Southeast Alaska in over 30 years. Heavy defoliation in 1983 produced substantial top-kill and tree mortality on nearly 10,000 acres of old growth western hemlock in the southern half of the Tongass National Forest. Several small-scale evaluations were carried out by Forest Pest Management personnel to assess tree recovery and to document the incidence of hemlock mortality and top-kill in some of the more heavily affected areas. Results of those evaluations and other observations on this extensive sawfly outbreak are presented in this report.


## INTRODUCTION

The hemlock sawfly, Neodiprion tsuage Middleton, (Appendix A) is an important defoliator of western hemlock (Tsuga heterophylla (Raf.) Sarg.) in southeastern Alaska and coastal British Columbia (Hard et al 1976). Recurrent outbreaks have been reported in coastal Alaskan forests since 1918 (Yarger 1978), most commonly in the southern half of the Tongass National Forest (Hard 1976). Heavy defoliation by the sawfly can produce top-kill or mortality although the majority of trees in an affected stand usually survive. Prior to the 1980's, the most recent outbreak of the hemlock sawfly occurred between 1965 and 1973 when 42,000 acres were defoliated, primarily on Prince of Wales, Revillagigedo, and Chichagof Islands. After a period of low sawfly populations, visible damage was detected in 1982, and increased dramatically in 1983 to cover over 60,000 acres. Several evaluations were carried out on the ground in heavily affected areas by Forest Pest Management personnel in order to assess damage levels and recovery potential of defoliated trees. The purpose of this report is to summarize the results of these field evaluations and to identify areas were salvage harvesting of damaged hemlocks could be considered.

## AERIAL/DEFOLIATOR SURVEY

Each year the forests of Southeast Alaska are surveyed from the air for insect and disease damage and infestations are mapped for resource managers. In conjunction with this aerial reconnaissance, ground checks are made for population assessment of major hemlock defoliators. About 90 locations are visited each year and defoliator larvae are collected by beating the foliage of hemlocks along the beach fringe. The numbers obtained from tree beating are compared with previous years' collections to determine trends in infestation levels.

The most recent hemlock sawfly infestation began in 1982 when 500 acres of defoliation were noted in Polk Inlet (Skowl Arm) and other inlets at the southern end of Prince of Wales Island. In 1983 the total defoliated area increased dramatically to 62,000 acres. Most of the damage occurred on Prince of Wales Island and Dall Island, with substantial defoliation also noted at

Mitchell Bay on Admiralty Island. The defoliation was predominantly on south-facing slopes and generally above 500 feet in elevation. In 1984 sawfly damage was evident on 71,000 acres, including areas previously defoliated which had not fully recovered from the sawfly feeding of 1983. In 1985 the total area showing sawfly feeding dropped to 24,000 acres as many trees attacked in 1983 now masked the older defoliation with new growth. Further declines in damage and population levels were noted in 1986, as sawfly feeding was mapped on only 18,000 acres. About 10,000 acres of this total consisted of scattered to heavy top-kill and tree mortality from the previous infestation and 8,000 acres represented new defoliation.

Larval numbers collected from the ground survey plots also reflected these population fluctuations as shown in the table below:

| Sawfly | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Acres defoliated | -- | -- | 0.5M | 62 M | 71 M | 24 M | 18 M |
| Larvae collected | 0.2M | 0.6M | 4 M | 14 M | 25 M* | 12 M | 4 M |
| % plots with larvae | 36 | 56 | 73 | 77 | 76 | 67 | 71 |

*One-half of this total collected from one plot

## GROUND SURVEY METHODS

During the peak of sawfly activity in 1983, damage was widespread in the Tongass National Forest and several resource managers voiced concern over the possible effects of the insect infestation. In order to help determine the effects of sawfly feeding, ground surveys were carried out in five areas between 1983 and 1985. These five areas are shown in Figure 1. In the first four areas, defoliated trees were tagged so that they could be revisited the following year to document reinfestation by the sawfly or recovery from attack. In the fifth area (Dall Island), a one-time ground survey was conducted to assess the impact of sawfly on heavily defoliated trees. Specific survey procedures are briefly described below for each of the areas.

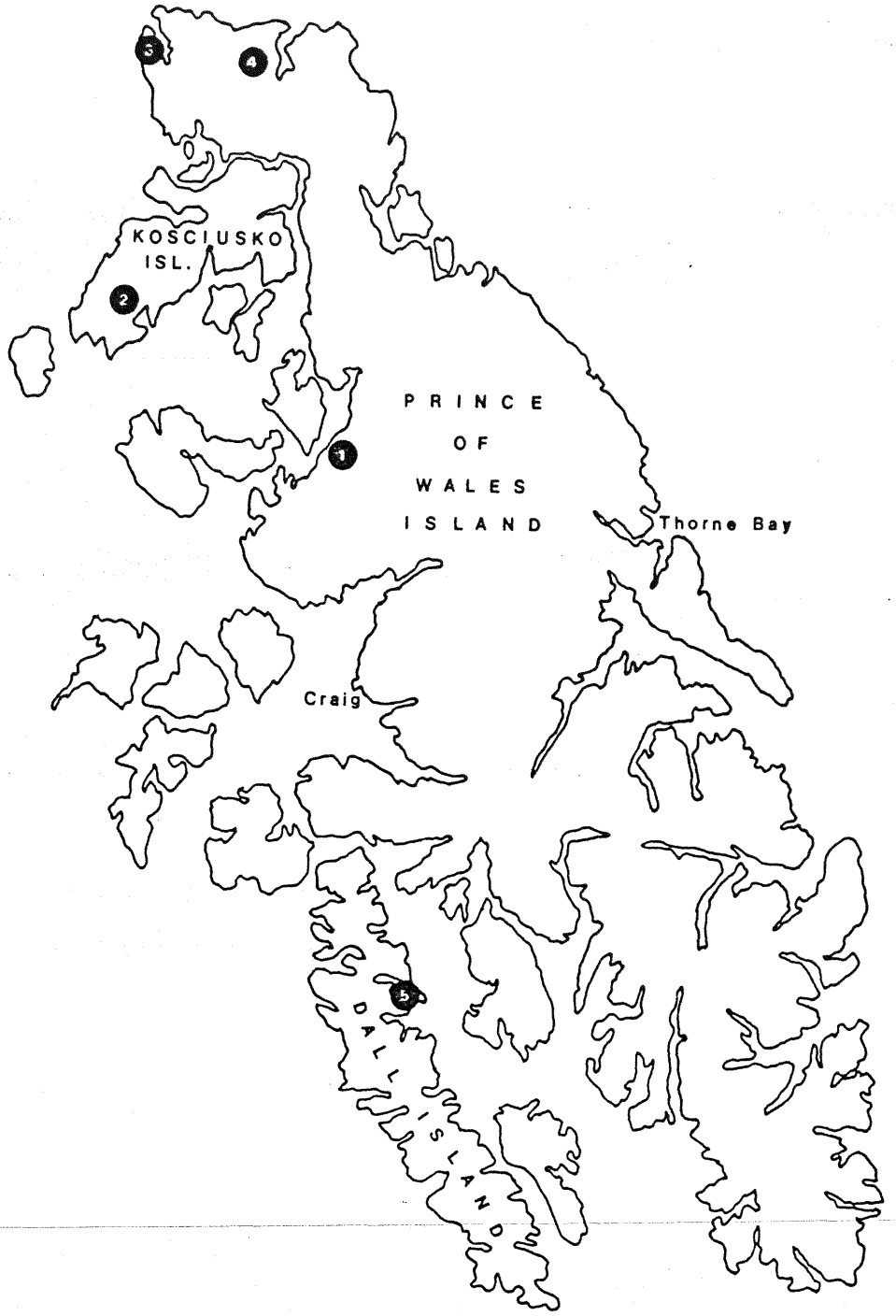


Figure 1. Locations of five survey areas on Prince of Wales, Kosciusko and Dall Islands for assessment of hemlock sawfly damage. 1983-1985.

1. Staney Creek R 80 E, T 70 S, Section 17

This survey area was located on the west side of Prince of Wales Island near Tuxekan Passage. A defoliated stand of old growth western hemlock was selected along Road 2050, three miles west of the Staney Creek bridge.

Sixty-nine defoliated trees within the stand were tagged at breast height with numbered aluminum tree tags. We recorded distances and bearings between successively numbered trees to aid in relocating them. For each tree the diameter was estimated to the nearest inch and the level of defoliation was rated as light, moderate, or heavy in both the upper and lower halves of the crown. Since our goal was to monitor recovery from defoliation, we chose trees that had sustained moderate to heavy damage and avoided trees with little defoliation which were interspersed among our sample trees. Trees were initially tagged in October 1983 and were re-examined in August 1984 when they were once again rated for defoliation level.

2. Survey Creek R 76 E, T 68 S, Section 30.

This survey area was located on the southern end of Kosciusko Island near Edna Bay. The defoliated stand consisted of young spruce and hemlock undergoing precommercial thinning. Both spruce and hemlock had sustained sawfly damage during the 1983 season prior to thinning.

In October 1983, 165 trees were tagged at breast height with aluminum tree tags, and compass bearings between successive trees were recorded. More spruce than hemlock were tagged, since sawfly feeding appeared to be more extensive on the spruce. Tree heights were estimated to the nearest foot. The trees were re-examined in August, 1984.

3. Labouchere Bay R 75 E / R 76 E, T 64 S, Sections 31, 36

The Labouchere Bay survey area was located at the edge of an old cutting unit just north of Hole-in-the-Wall at the northern end of Prince of Wales Island. The old growth stand of western hemlock was situated on a steep south-facing slope with access from Road 2092. We tagged 203 defoliated trees in September 1984 and re-examined them in September 1985 for recovery or mortality.

4. Red Bay R 78 E, T 65 S, Section 5

The Red Bay survey area was located above a cutting unit along Big Creek (Road 20-805) at the northern end of Prince of Wales Island. The stand contained old growth western hemlock with some Sitka spruce on a steep south-facing slope. We tagged 61 trees in September 1984 and re-examined them in September 1985.

5. Dall Island R 81 E, T 78 S / T 79 S, Sections 34, 3

Ground work on Dall Island was done from a base camp at Green Inlet in View Cove in the northeastern part of the island. Damage to hemlocks appeared to be heavier in this area than in any other location in Southeast Alaska. From the air, we had noted that most defoliated trees appeared bare in the upper crown. In order to make a better assessment of total sawfly damage we wanted to do a ground survey of the condition of lower crowns which were not visible from the air. In the ground survey, we walked along an arbitrarily established transect and looked for defoliated hemlocks. Sample trees were any trees along the transect which had no foliage in the upper half of the crown. For each sample tree we measured the diameter at breast height and estimated the amount of remaining live crown. On totally bare trees we chopped into the cambium to determine if the trees had died from the 1983 defoliation. 195 trees were examined in August 1985.

## RESULTS OF GROUND SURVEY

1. Staney Creek

Hemlock sawfly feeding was heavier in the upper crowns of affected trees. In 1983, the average tree tagged in the Staney Creek area had sustained heavy defoliation. The sawfly did not reattack these trees in 1984, and all showed some degree of recovery that year. The average damage noted in 1984 was moderate defoliation, which means that the previous year's defoliation had been partially masked, and no new defoliation occurred. The average diameter of sample trees at Staney Creek was 15.3" dbh. Trees less than 15" dbh (predominantly intermediates or understory trees) showed slightly better recovery than did trees larger than 16" dbh (codominants and dominants).

2. Survey Creek

The heights of sample trees in the Survey Creek area averaged 14.2 feet for western hemlock and 10.3 feet for Sitka spruce.

We noted different patterns of sawfly feeding on young Sitka spruce and western hemlock. Most of the defoliation on hemlock was distributed throughout the interior crown (older needles) and on 15% of the trees feeding was heavier on the lower half of the crown. On spruce, however, the feeding was usually heavier in the tops of affected trees, and often was confined strictly to the outer or most recently produced foliage. A common pattern of damage on Sitka spruce was to find the top quarter to two-thirds of the tree stripped bare, with only the outer foliage consumed in the lower crown. About 12% of the tagged spruce had sustained total defoliation of the upper three-quarters of the crown.

When we re-examined the area in 1985, we noted that most trees had recovered to a substantial degree even though they were still being exposed to light sawfly attack. The damage on the average tagged hemlock decreased from moderate defoliation in 1984 to light defoliation in 1985. For spruce, virtually all trees showed good recovery unless they had sustained complete defoliation in more than three-quarters of the crown. Of the 13 trees affected this heavily in 1984, only four showed good regrowth in 1985. The other nine suffered top-kill or produced severely stunted shoots. There did not appear to be any connection between tree height and recovery from previous sawfly damage.

3. Labouchere Bay

Trees in the Labouchere Bay sampling area ranged in diameter from 3.5" to 33.0" dbh and averaged 11.8". In both the overstory and understory trees, sawfly damage was heavier in the top halves of the crowns. During our initial survey in 1984, 72% of the 203 tagged trees had the tops completely defoliated. Defoliation was slightly lower but still heavy in the tops of 47 additional trees. When we returned in 1985, the tagged trees had not been reattacked. Those few trees which had sustained lighter damage appeared to recover. Many of the heavily defoliated trees were dead in 1985 or showed no recovery from previous defoliation. On our revisit in 1985 we found that 76 trees were dead (37% of the total) and another 71 are probable top-kills.

In this area the smaller understory trees, although not attacked any harder initially, suffered proportionately greater levels of mortality than the larger trees. For trees less than 11.8" dbh, 55 of 113 had died from severe defoliation, while among the trees larger than 11.8" dbh, only 21 of 90 were dead in 1985.

4. Red Bay

In the Red Bay survey area, the average diameter of 61 tagged trees was 17.3" dbh. Similar to other areas, sawfly defoliation was heavier in the tops of trees, both in the overstory and understory. When the trees were tagged in the fall on 1984, 50 of the 61 trees had bare tops, with heavy defoliation in nine others. Thirteen of these heavily defoliated trees died in 1985. Eleven of the 13 dead trees were smaller than the average diameter, once again suggesting that the smaller understory trees are less capable of recovery than larger codominants and dominants. Trees with lighter defoliation showed fair recovery in 1985, although an additional 25 trees have probably sustained top-kill from the one-time defoliation.

5. Dall Island

A total of 195 trees with defoliated tops were examined in the View Cove area in August, 1985. The hemlock sawfly had killed 53 of these trees (27% of our sample) and 23 additional trees were dying (less than 5% of the live crown remained). Of the other trees we considered alive, 30 had only 5% of the crown remaining, and another 36 trees had 10-15% of the crown remaining. In total, 73% of our sample trees were either dead, dying, or had less than 15% of the live crown remaining. In all cases, sawfly feeding was greatest in the upper crown, and where foliage remained, it was usually on one or two basal branches.

The average diameter of sample trees in the Dall Island area was 20.6" dbh. There was no apparent correlation between size class and mortality. Live trees averaged 21.5" dbh (ranging from 6.4" to 47.0" dbh) and dead and dying trees averaged 19.5" dbh (ranging from 6.1" to 39.6" dbh).

## CONCLUSIONS/SALVAGE RECOMMENDATIONS

From our aerial survey and ground observations we conclude that most of the damage caused by the hemlock sawfly occurred in 1983. Even though we noted comparable acreages of damage in 1984, much of this area included trees with lingering symptoms of previous defoliation from 1983. An area of moderate defoliation in one year may appear lightly defoliated the next year even though trees are not attacked that year. The crown symptoms in such a case would be difficult to distinguish from light current defoliation.

We noted that when trees retain their current growth (i. e., are lightly to moderately defoliated), they usually recover and mask the defoliation within one or two years. When current foliage is also consumed, as was the case in areas mapped as heavily defoliated, recovery may be much slower, if it happens at all. We believe that any tree that still looks bare two years after attack will probably not recover. Since sawfly damage was consistently heavier in the tops of trees (except in young growth stands), there may be a tendency to overestimate tree mortality from aerial observation. Many trees which appear dead when viewed from the air may simply have top-kill, with live basal branches which are obscured from view. From a practical standpoint, however, there may be little distinction between tree mortality and severe top-kill, and defoliated areas may be evaluated for salvage on the basis of the percent of bare-topped trees in a stand. The distribution of severely affected trees is usually patchy and often dead and dying trees are mixed in with trees that recovered fully from previous defoliation. The maps that follow indicate areas where we have detected patches of bare-topped hemlocks which did not recover from the 1983-84 sawfly infestation (slightly more than 10,000 acres). The hemlock mortality and top-kill ranges from 10 to 70% of the stand in these areas, with rough percentages indicated. All these areas could be considered for salvage if such operations are compatible with the regular harvesting schedule. A good rule of thumb for dealing with currently infested areas would be to let them go for two to three years after defoliation is first observed. Most trees will probably recover, and any that don't recover after two or three

years have probably sustained top-kill at least, and could then be scheduled for salvage. The ability of hemlocks to recover has been fairly remarkable in many areas, and judgments of mortality should not be made prematurely, even where the initial defoliation appears to be heavy.

## REFERENCES

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Hard, John S. 1976. Natural control of hemlock sawfly, Neodiprion tsugae (Hymenoptera:Diprionidae) populations in southeast Alaska. Can. Ent. 108: 485-498.

Hard, John S., Torolf R. Torgerson and Donald C. Schmiege. 1976. Hemlock sawfly. USDA Forest Service, Forest Insect & Disease Leaflet 31, 7 p.

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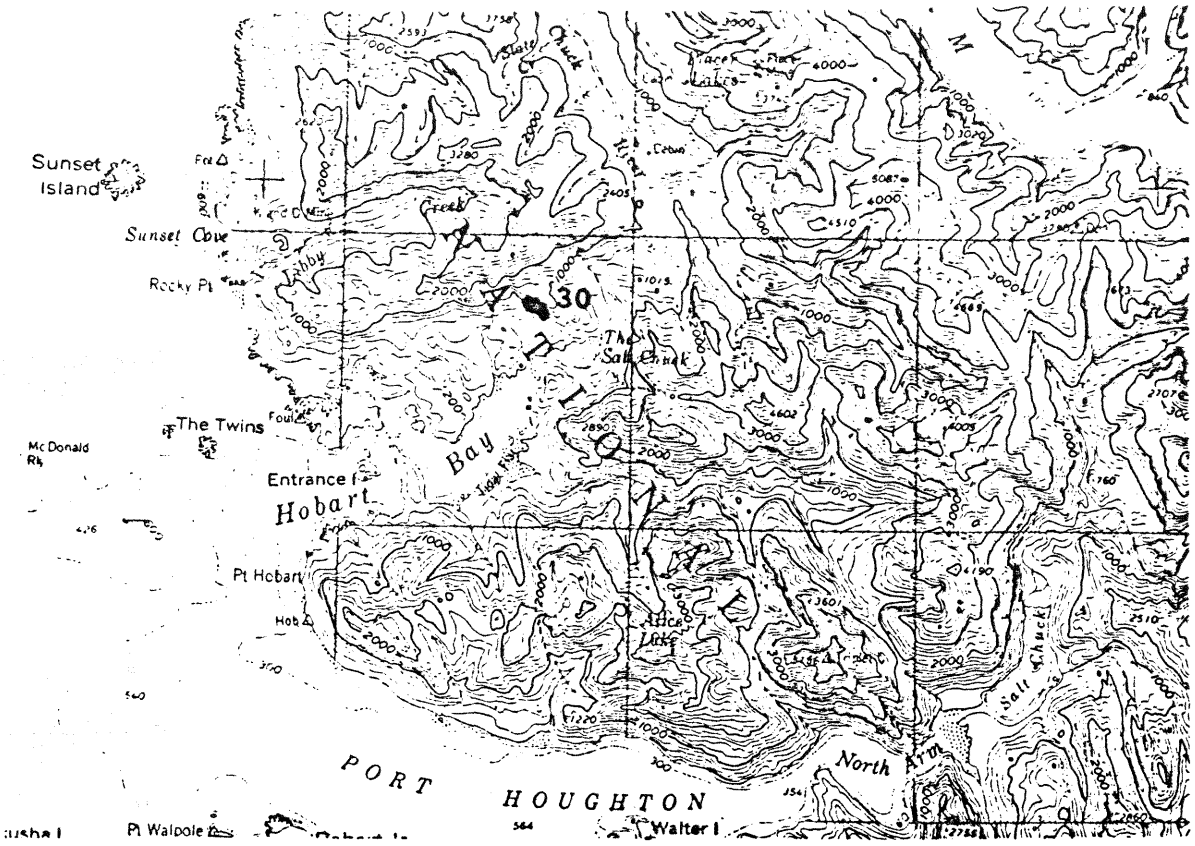
NUMBERS ON THE FOLLOWING MAPS INDICATE PERCENT OF TREES THAT APPEAR TO BE DEAD OR TOP-KILLED WITHIN THE AFFECTED AREAS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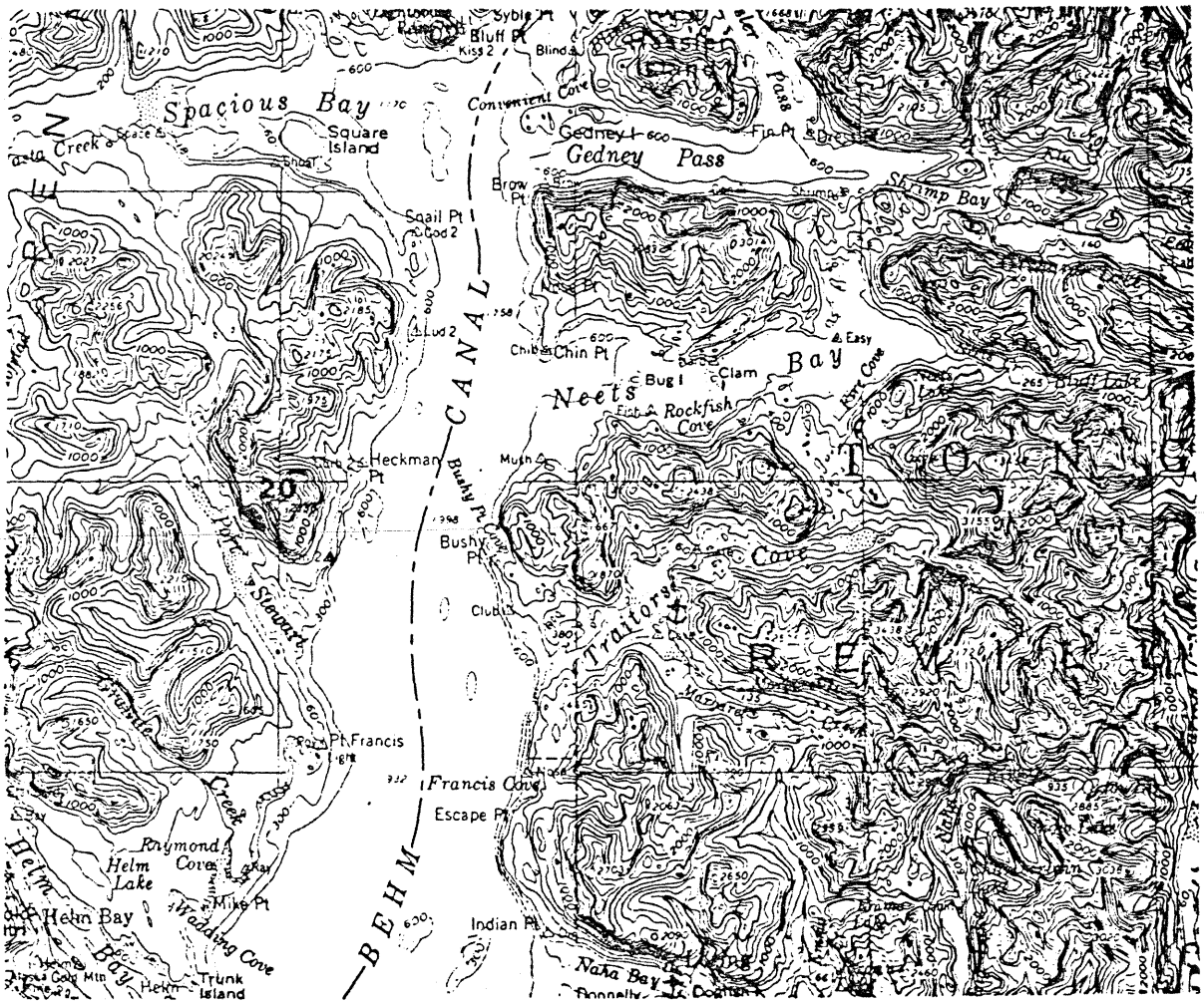
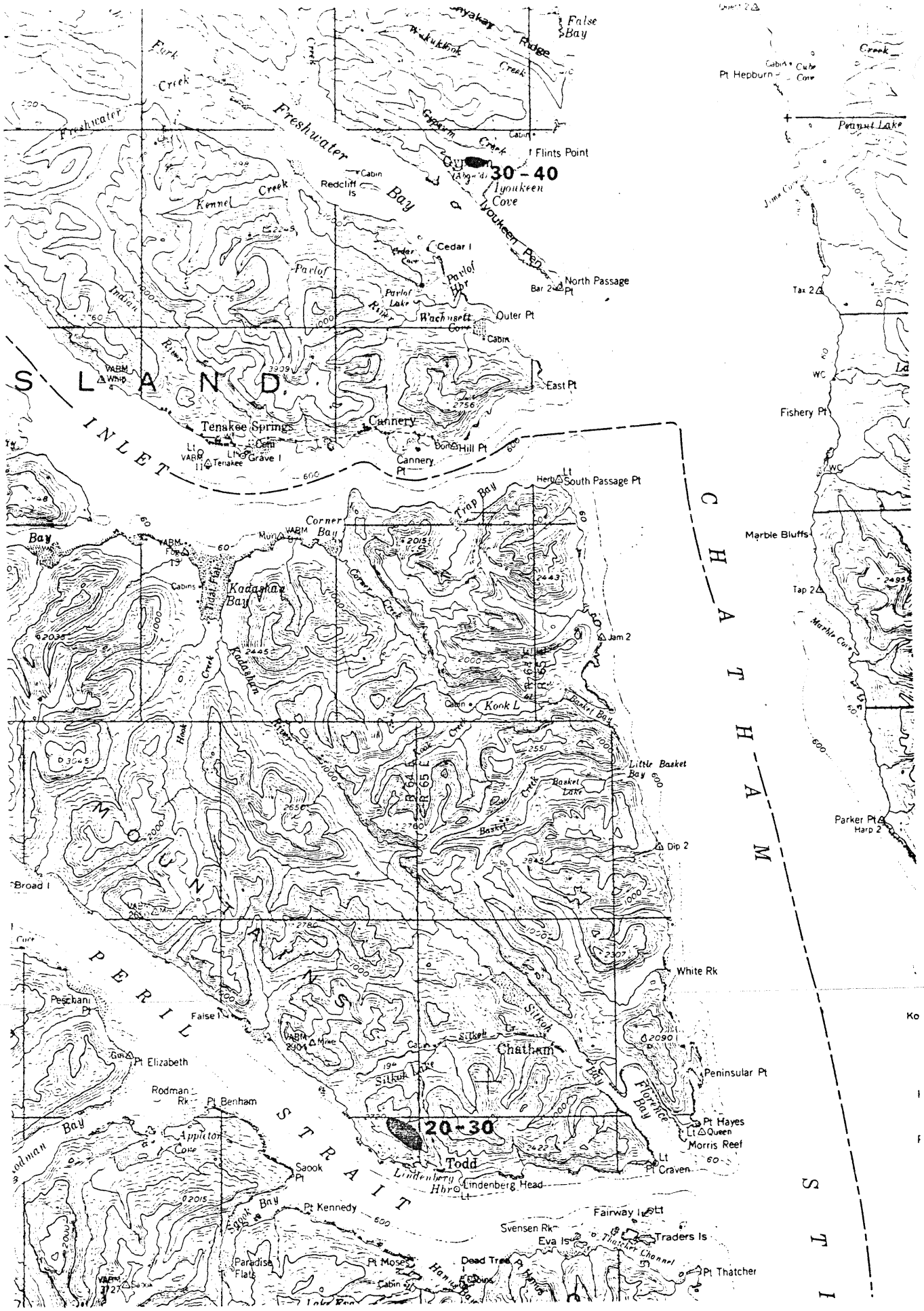
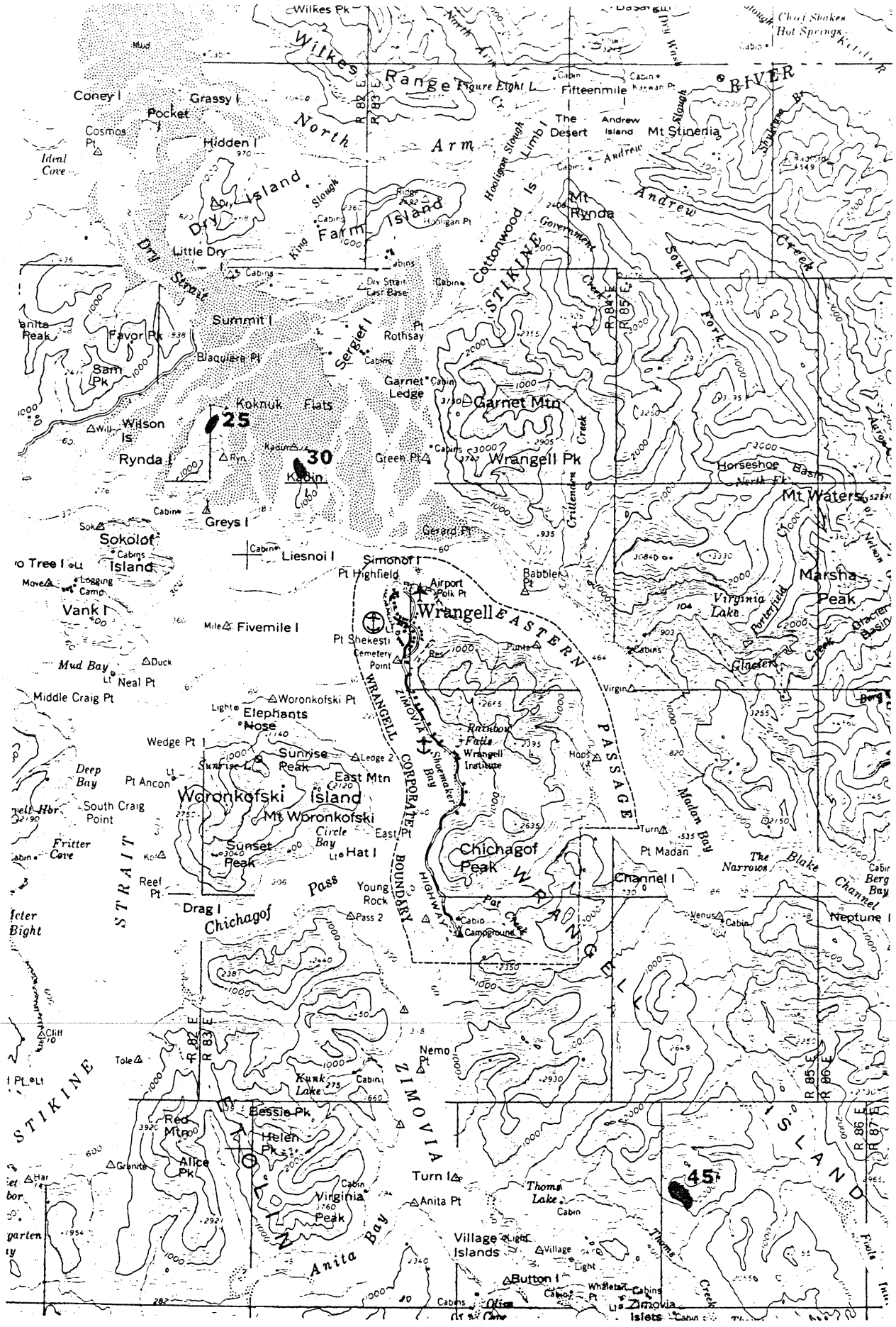
Sunset Cove
Rocky Pt
The Twins
Mc Donald Rk
Entrance I
Hobart
Pt Hobart
Hob
Alice Lake
Salt Chuck
North Arm
PORT HOUGHTON
Pt Walpole
Walter I
30


Spacious Bay
Square Island
Convenient Cove
Gedney Pass
Shrimp Bay
Brow Pt
Snail Pt
Cod 2
Lud 2
Chin Pt
Bug I
Clam Bay
Neets Bay
Rockfish Cove
Heckman Pt
Bushy Pt
Cove
Traitors
Port Stewart
Pt Francis
Francis Cove
Escape Pt
Raymond Cove
Helm Lake
Helm Bay
Mike Pt
Wedding Cove
Trunk Island
Indian Pt
Nata Bay
BEHM CANAL
20


False Bay
Freshwater Bay
Freshwater Creek
Kennel Creek
Redcliff Is
Cabin
Flints Point
30 - 40
Tyoukeen Cove
Tyoukeen Pass
Cedar I
Parlof Hbr
Parlof Lake
Parlof River
Indian River
North Passage Pt
Outer Pt
W'achusett Cove
East Pt
S L A N D.
I N L E T
Tenakee Springs
Cannery
Hill Pt
Cannery Pt
Grave I
Tenakee
South Passage Pt
Trap Bay
Corner Bay
Kadashan Bay
Kadashan River
Kadashan Creek
Konk L
Basket Bay
Basket Creek
Basket Lake
Little Basket Bay
Jam 2
Dip 2
Broad I
M O U N T
A N S
White Rk
Peschani Pt
False N
Pt Elizabeth
Rodman Bay
Rodman Rk
Pt Benham
Appleton Cove
Saook Pt
Sitkoh
Sitkoh Bay
Sitkoh Lake
Chatham
Peninsular Pt
Florence Bay
Pt Hayes
Queen
Morris Reef
Craven
20 - 30
Todd
Lindenberg Head
Fairway I
Svensen Rk
Eva Is
Traders Is
Pt Kennedy
Eagle Bay
Paradise Flats
Pt Moser
Dead Tree Pt
Pt Thatcher
P E R I L
S T R A I T
C H A T H A M
S T R A I T
Pt Hepburn
Cabin
Cube Cove
Peanut Lake
Jinx Cove
Tax 2
Fishery Pt
WC
Marble Bluffs
Marble Cove
Tap 2
Parker Pt
Harp 2


Wilkes Pk
Wilkes Range
North Arm
Coney I
Grassy I
Pocket
Cosmos Pt
Hidden I
Ideal Cove
Dry Island
Dry Island Farm
Little Dry
Dry Strait
Summit I
Favor Pk
Sam Pk
Blaquiere Pt
Sergief I
Pt Rothsay
Koknuk Flats
25
30
Wilson Is
Rynda I
Kadin
Green Pt
Greys I
Sokolof Island
Liesnoi I
Simonof I
Pt Highfield
Airport
Polk Pt
Wrangell
Pt Shekesti
Cemetery Point
Vank I
Fivemile I
Mud Bay
Neal Pt
Middle Craig Pt
Woronkofski Pt
Elephants Nose
Wedge Pt
Sunrise Peak
Ledge 2
East Mtn
Deep Bay
Pt Ancon
Woronkofski Island
Mt Woronkofski
South Craig Point
Fritter Cove
Sunset Peak
Circle Bay
East Pt
Hat I
Reef Pt
Drag I
Young Rock
Pass 2
Chichagof
Peter Bight
STRAIT
STIKINE
Cliff
Tole
Kunk Lake
Bessie Pk
Red Mtn
Helen Pk
Alice Pk
Granite
Virginia Peak
Anita Bay
ZIMOVIA
Nemo Pt
Turn I
Anita Pt
Village Islands
Button I
Zimovia Islets
Fifteenmile
The Desert
Andrew Island
Mt Stuenia
Mt Rynda
Andrew Creek
South Fork
Cottonwood Is
Garnet Ledge
Garnet Mtn
Wrangell Pk
Horseshoe Basin
Mt Waters
Marsha Peak
Virginia Lake
Babbler Pt
Rainbow Falls
Wrangell Institute
Shoemaker Bay
Pt Madan
Channel I
Madan Bay
The Narrows
Blake Channel
Neptune I
Berg Bay
Chichagof Peak
WRANGELL
EASTERN PASSAGE
WRANGELL-ZIMOVIA CORPORATE BOUNDARY
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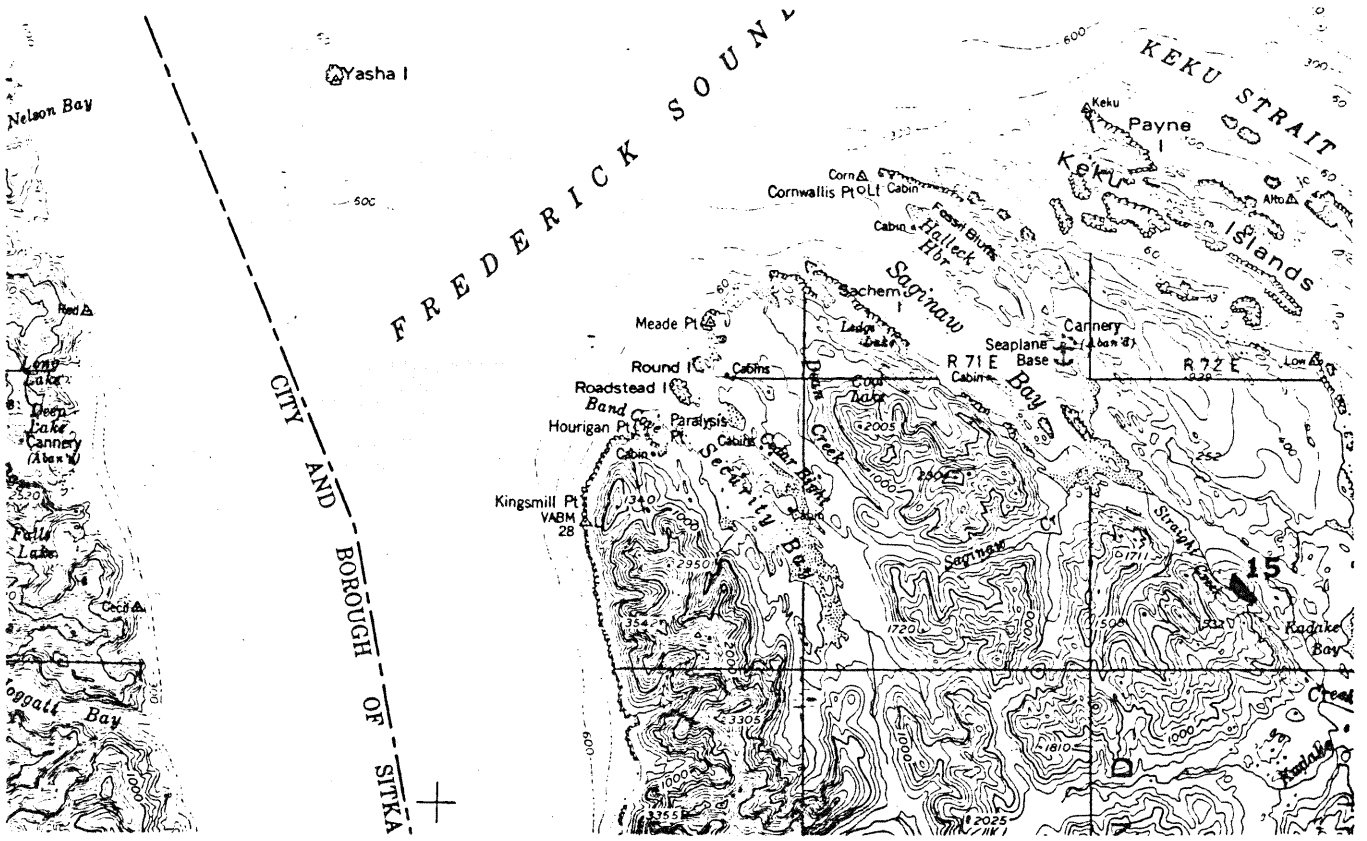
R 83 E
R 84 E
R 85 E
R 86 E
R 87 E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Nelson Bay
FREDERICK SOUND
CITY AND BOROUGH OF SITKA
KEKU STRAIT
Keku Islands
Payne I
Cornwallis Pt Lt
Halleck Hbr
Sagimaw Bay
Meade Pt
Round I
Roadstead I
Band Cove
Hourigan Pt
Paralysis Pt
Kingsmill Pt
VABM 28
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R 72 E
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Redake Bay
Deep Lake
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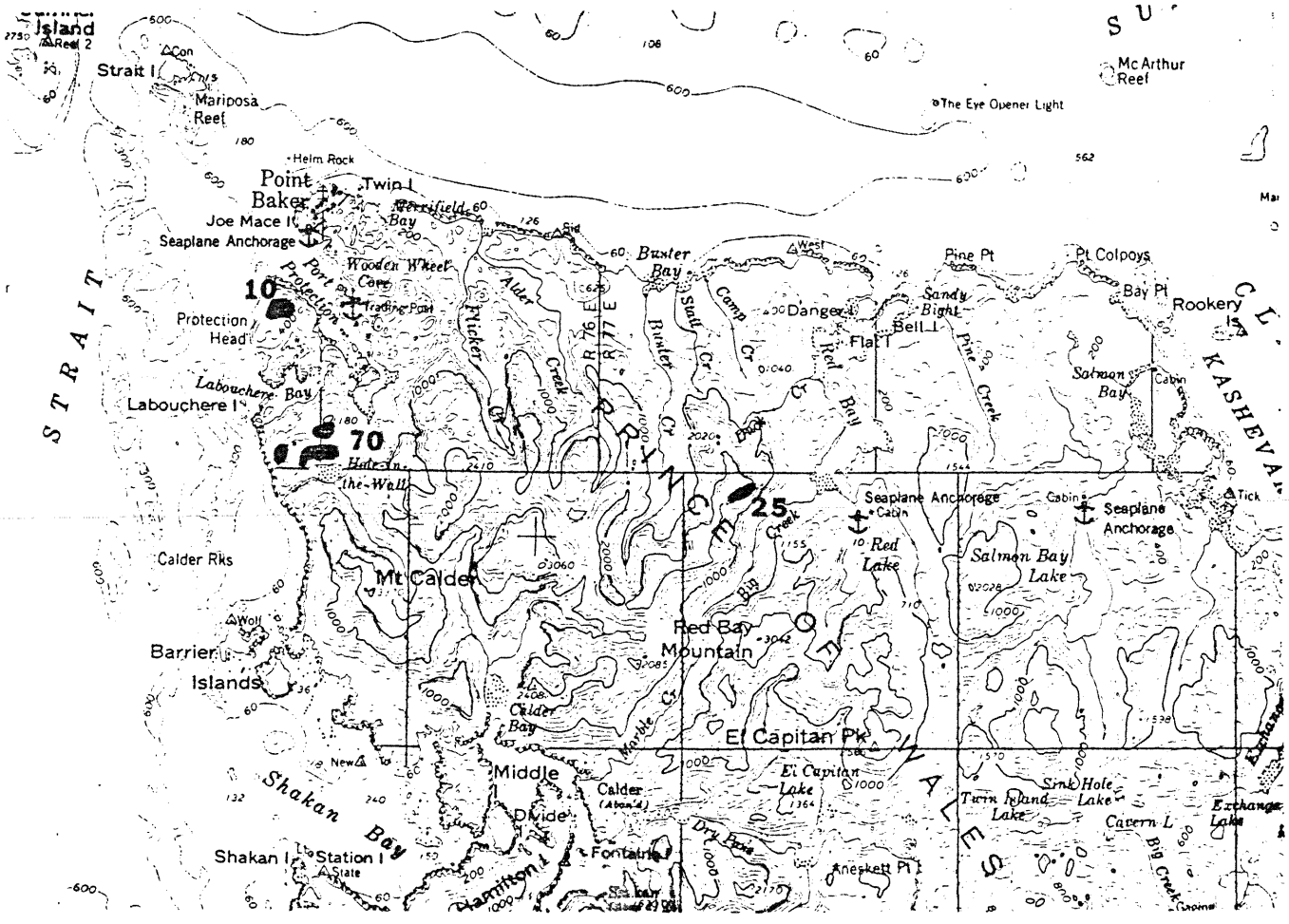
Loggait Bay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Strait I
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Joe Mace I
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Twin I
Merrifield Bay
Helm Rock
Wooden Wheel Cove
Trading Post
Port Protection
10
Protection Head
Labouchere Bay
Labouchere I
70
Hole-in-the-Wall
Alder Creek
Flicker Creek
R 76 E
R 77 E
Buxton Bay
Danger Pt
Flat I
Bell I
Sandy Bight
Pine Pt
Pt Colpoys
Bay Pt
Rookery
Salmon Bay
Cabin
Mc Arthur Reef
The Eye Opener Light
STRAIT
KASHEVAROV
Calder Rks
Mt Calder
Barrier Islands
Red Bay Mountain
25
Red Lake
Salmon Bay Lake
Seaplane Anchorage
Tick
Shakan Bay
Middle I
Calder Bay
Calder (Abnd)
Divide
Shakan I
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Exchange Lake
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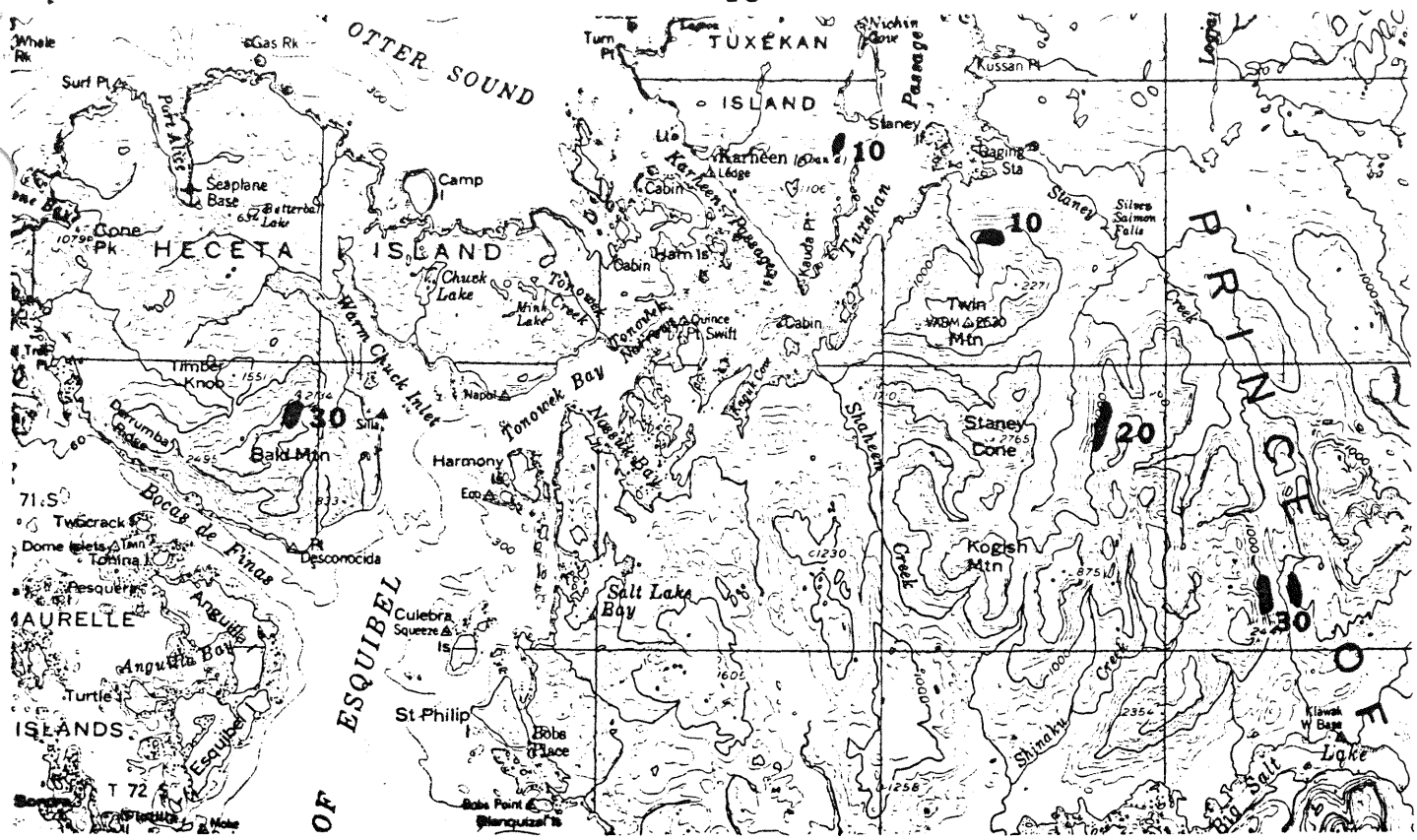
OTTER SOUND
TUXEKAN ISLAND
Tuxekan Passage
Karheen
Cabin
Camp
Seaplane Base
Cone Pk
HECETA ISLAND
Warm Chuck Inlet
Tonowek Bay
Timber Knob
Bald Mtn
Harmony
Twocrack
Dome Islets
Tonina
Pesquero
Bocas de Finas
Pt Desconocida
Culebra Squeeze Is
Salt Lake Bay
Kogish Mtn
Staney Cove
Twin Mtn
Staney Creek
Shinaku Creek
Klawock W Base
Klawock Lake
St Philip I
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OF ESQUIBEL
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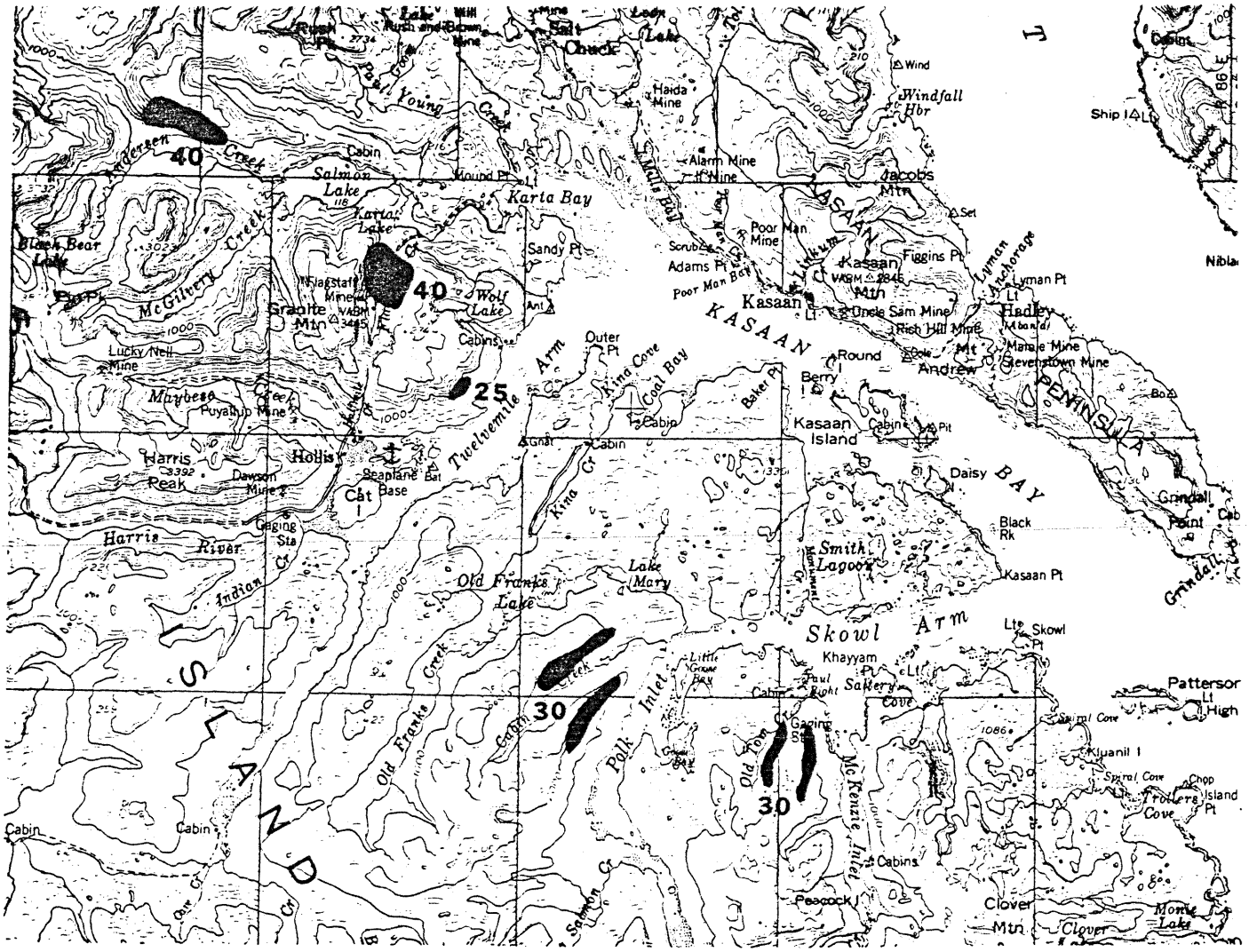
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Wolf Lake
Sandy Pt
Poor Man Mine
Adams Pt
Kasaan Mtn
Figgins Pt
Lyman Pt
Hadley Mt
Uncle Sam Mine
Rich Hill Mine
Maple Mine
Stevenstown Mine
Andrew
Round I
Berry I
Kasaan Island
Kasaan Peninsula
Daisy Bay
Black Rk
Kasaan Pt
Smith Lagoon
Skowl Arm
Lt Skowl Pt
Khayyam
Saukery Cove
Pattersor Lt
High
Outer Pt
Coal Bay
Baker Pt
Lucky Nell Mine
Maybeso Creek
Puyallup Mine
Harris Reak
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Cat I
Harris River
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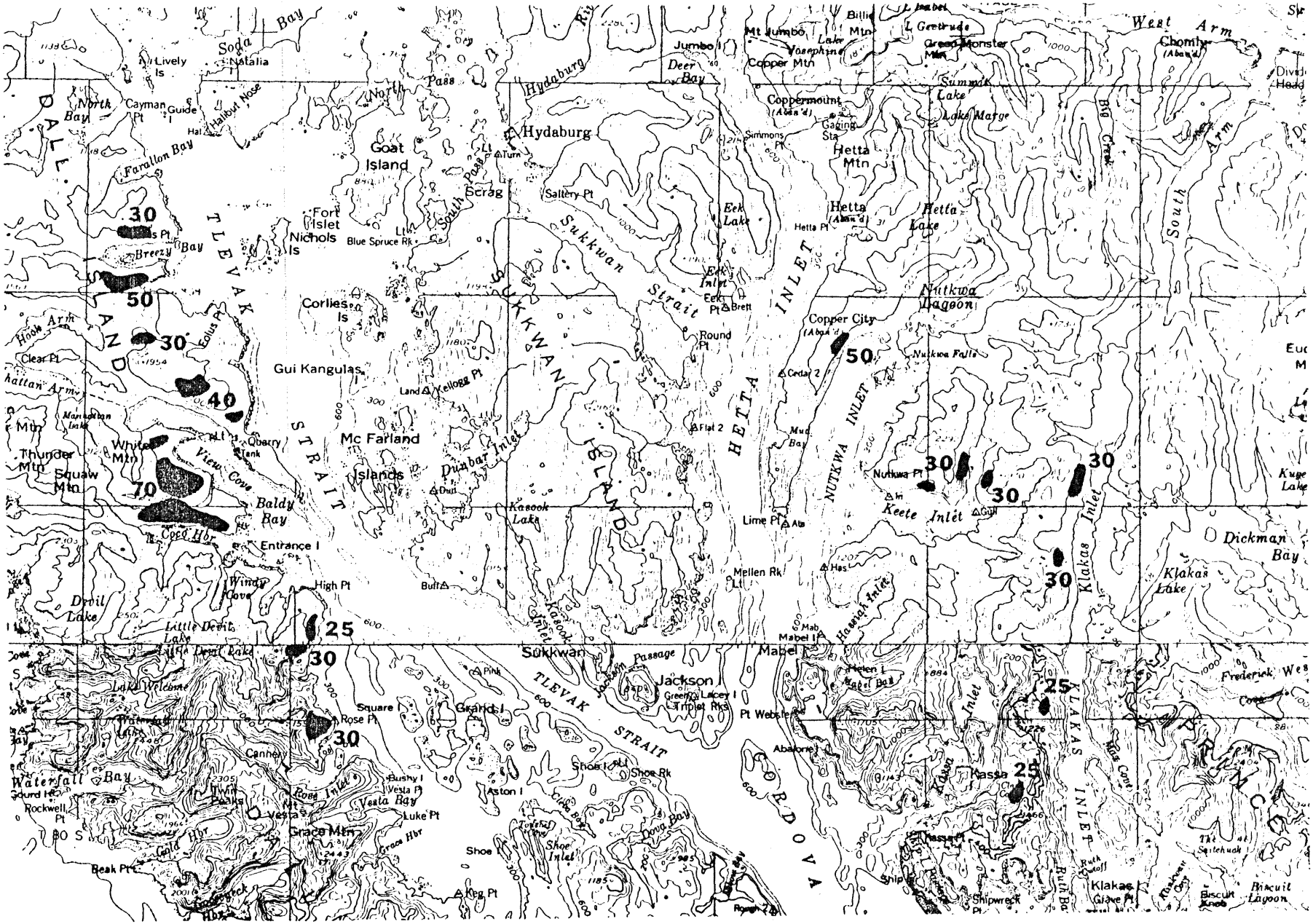
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Natalia
North Bay
Cayman Pt
Guide I
Halibut Nose
North Pass
Hydaburg
Deer Bay
Jumbo
Mt Jumbo
Billie Mtn
Copper Mtn
Josephine
Gertrude Lake
Green Monster Mtn
West Arm
Chomly (Abnd'd)
Coppermount (Abnd'd)
Gaging Sta
Simmons Pt
Hetta Mtn
Summit Lake
Lake Marge
Big Creek
South Arm
Farallon Bay
Goat Island
Scrag
South Pass
Saltery Pt
Hetta (Abnd'd)
Hetta Pt
Eek Lake
Hetta Lake
Fort Nichols Is
Islet
Blue Spruce Rk
Breezy Bay
Sukkwan Strait
Eek Inlet
Eek Pt
Brett
Nutkwa Lagoon
Copper City (Abnd'd)
Corlies Is
Hook Arm
Clear Pt
Round Pt
Nutkwa Falls
Cedar 2
Gui Kangulas I
Land
Kellogg Pt
Flat 2
Mud Bay
Nutkwa Pt
Keete Inlet
Gull
Lime Pt
Alb
Mellen Rk
Has
Dickman Bay
Klakas Lake
Klakas Inlet
Thunder Mtn
White Mtn
Squaw Mtn
Quarry
Tank
Mc Farland Islands
Dunbar Inlet
Dun
Kasook Lake
Baldy Bay
View Cove
Coco Hbr
Entrance I
Windy Cove
High Pt
Devil Lake
Little Devil Lake
Bull
Kasook Inlet
Sukkwan
Mabel
Mab
Mabel Bay
Haasiah Inlet
Jackson
Green I
Lacey I
Triplet Rks
Pt Webster
Passage
Pink
Grand I
Square
Rose Pt
Canoe Pass
Waterfall Bay
Rockwell Pt
Twin Peaks
Rose Inlet
Mt Vesta
Vesta Pt
Vesta Bay
Luke Pt
Grace Mtn
Grace Hbr
Gold Hbr
Beak Pt
Rushy I
Shoe I
Shoe Rk
Aston I
Shoe
Shoe Inlet
Tokeshi Pt
Dena Bay
Kog Pt
Abalone I
Kassa
Kassa Inlet
Shipwreck
Shipwreck Pt
Klakas Grave Pt
Ruth Cove
Biscuit Knob
Biscuit Lagoon
The Switchback
Frederick
30
50
40
70
25
TLEVAK STRAIT
SUKKWAN ISLAND
HETTA INLET
NUTKWA INLET
KLAKAS INLET
CORDOVA
PRINCE

# APPENDIX A

## HEMLOCK SAWFLY

## *Neodiprion tsugae* Middleton

## (Hymenoptera:Diprionidae)

HOSTS: Primarily western hemlock; also Sitka spruce, mountain hemlock and Pacific silver fir if growing near infested western hemlock.

DISTRIBUTION: Coastal forests of Southeast Alaska, British Columbia, Washington, and Oregon. Also occurs in the interior of British Columbia, Idaho and Montana.

DAMAGE: Larvae feed preferentially on older foliage of western hemlock. Current year's needles may also be consumed once the older needles have been depleted, sometimes resulting in top-kill or tree mortality.

DESCRIPTION: Eggs are pale yellow and are laid singly inside the margins of host needles. Young larvae are nearly black upon emergence, and later turn dark green. When nearly fully grown, the larva develops longitudinal stripes and is distinguished from lepidopteran larvae by having eight pairs of abdominal legs. Larvae have black head capsules in each of their four to five instars. Mature larvae are 15 to 20 mm long. The pupal stage is contained in a tough papery cocoon that is cylindrical with rounded ends and golden brown in color. Adult sawflies are 5-8 mm long, with females slightly larger than males. Females are yellow or brownish and have serrated antennae; males are black with plumed antennae.

BIOLOGY: The hemlock sawfly overwinters in the egg stage and larvae hatch out in June. Young larvae feed in groups on the old foliage; as they mature the larvae disperse and feed singly until pupation. Male larvae pass through four feeding instars while females have five. After feeding is completed, the larvae spin cocoons on needles and twigs, on understory shrubs, or in the duff. Adult sawflies emerge from the cocoons from August to October, with males normally emerging

earlier than females (Hard et al 1976). Females deposit eggs in slits cut along the edges of current year's needles. Robust females can produce an average of 60 to 70 eggs, although individual fecundity may vary from 10 to 100 eggs, depending on the degree of host defoliation and its effect on individual female vigor (Hard et al 1976).

Natural controls that are important in regulating sawfly populations include adverse weather, a fungal disease, and associated parasitic wasps. Cold weather in the summer and fall affect the sawfly directly by delaying maturation of larvae, reducing female fecundity, and inhibiting oviposition (Hard et al 1976). Since 1950, most negative trends in sawfly populations have occurred after two consecutive wet seasons (Hard 1976). The fungus Entomophthora sphaerosperma spreads most readily throughout larval populations during wet summers. When summers are dry, three pupal parasites become more effective as natural controls. An important feedback mechanism exists within the host plant, which helps to limit large-scale sawfly populations. When larvae are forced to feed on new foliage late in their development, insect survival is dramatically reduced, especially in females, and fecundity of surviving females is also reduced (Hard 1971).